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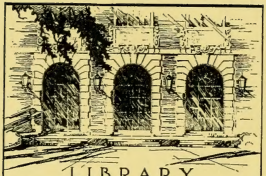

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LEAD POISONING IN WILD WATERFOWL

James S. Jordan and Frank C. Bellrose

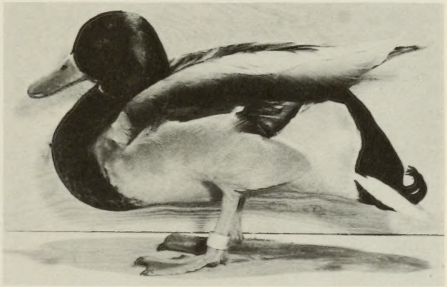

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Fig. 1. -- Duck pens located at the Quiver Creek laboratory of the Illinois Natural History Survey, on the Chautauqua National Wildlife Refuge, near Havana, Illinois. Enclosures have held Pekin ducks, wild mallards, game-farm mallards, blue-winged teals, and Canada geese for studies on the effects of ingested shot pellets.

LEAD POISONING IN WILD WATERFOWL

James S. Jordan and Frank C. Bellrose
Illinois Natural History Survey

For more than half a century, sportsmen and conservationists have been aware of losses resulting from lead poisoning among the wild waterfowl of North America. Competent observers have made counts of the numbers of birds involved in some of the sporadic, local die-offs, but little information has been available for making even rough estimates of the over-all continental losses resulting from lead poisoning.

For several years, biologists with the Illinois Natural History Survey have been aware of lead-poisoning die-offs that have occurred among migratory waterfowl within the state almost annually in December or January. A spectacular die-off of mallard ducks near Grafton in January, 1947, prompted a joint investigation by the Natural History Survey and the United States Fish and Wildlife Service. A still greater die-off in the same area a year later attracted the attention of officials of the Western Cartridge Company of East Alton. As an outgrowth of the situation, a co-operative investigation of lead poisoning in waterfowl was begun in July, 1948, by the Illinois Natural History Survey, the Western

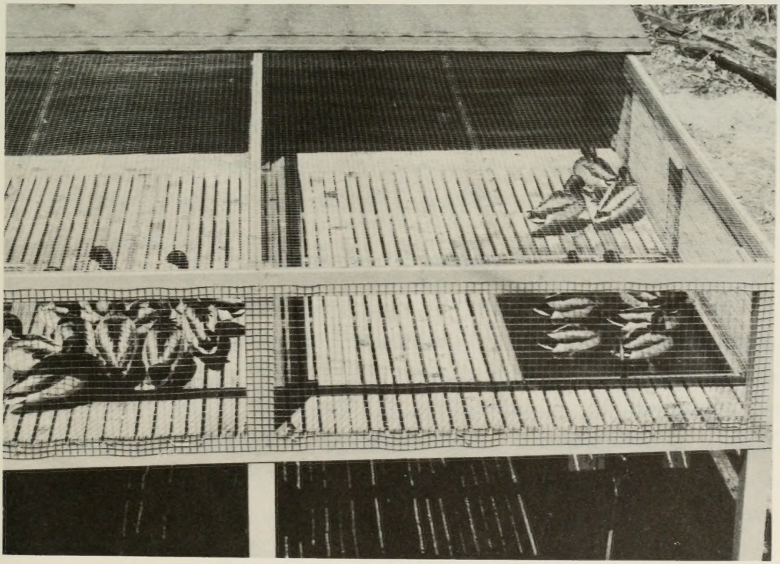

Fig. 2. -- Ducks in two of pens shown in fig. 1. Jet pumps furnish a constant supply of fresh water.

Cartridge Company, which is a Division of the Olin Industries, Inc., and the University of Illinois. In the course of the investigation, many other agencies and individuals have given assistance.

The purposes of the investigation were (1) to evaluate the losses in waterfowl from lead poisoning and (2) to attempt to reduce these losses by developing and introducing a nontoxic shot. Information on lead poisoning was obtained through study of pertinent findings already published, through experimentation with penned ducks, figs. 1 and 2, and through extensive surveys of conditions in wild populations.

This paper is a preliminary report on the investigation, which, according to present plans, will be covered in greater detail and with supporting data in a future publication.

Contrary to popular belief, lead shot in the flesh of waterfowl does not cause lead poisoning. Shot pellets in the flesh undergo slight, if any, change and are of little harm to waterfowl unless they have damaged vital tissues.

Lead poisoning is likely to occur in waterfowl that have swallowed lead shot pellets while feeding on the bottoms of lakes and marshes. After a shot pellet has come to rest in the gizzard of a bird, the surface of the pellet is eroded and dissolved away through the grinding action of the gizzard and its contents and through the chemical action of the digestive juices, fig. 3. The lead undergoes further chemical change as it moves through the intestine. Some of the lead compounds that are formed are absorbed by the blood stream through the intestinal walls and apparently damage the liver and kidneys. Lead compounds also appear to have a direct harmful effect on the muscles of the digestive tract. The normal activity of these muscles may be reduced to such an extent that adequate digestion and assimilation of food are seriously impaired. Lead poisoning is the name given to the pathological condition that results.

SYMPTOMS OF LEAD POISONING

The public usually becomes aware of lead poisoning among waterfowl through spectacular local die-offs of birds late in fall or in winter. Because severe weather often limits the food supply at the time of such die-offs, the public has frequently attributed the losses to starvation associated with scarcity of available food. Some sportsmen know that the damage done by lead poisoning is not confined to die-offs of spectacular proportions. They recognize that the emaciated ducks they kill during the hunting season -- the birds they aptly term "straw hats" -- are in poor flesh as a result of lead poisoning or crippling gunshot wounds.

It is possible to recognize most cases of lead poisoning in waterfowl by observing the appearance and behavior of living birds and by examining the viscera of dead birds.

Fig. 8. -- Six shot pellets (small white circles) in the gizzard of a duck, as shown by X-ray.

Symptoms in Live Ducks. -- Results obtained from the experimental use of a large number of captive wild mallards show that the symptoms of lead poisoning follow a definite pattern. Typically, the development of each symptom is followed by an increase in its severity, and the combined effects of lead produce an illness of short duration, followed by death.

Of the external symptoms, one of the earliest to appear is lowered food intake. In every case the appetite of the affected bird either fails completely or food consumption falls to a level below minimum nutritional requirements, fig. 4. The correlative symptom is progressive loss of body weight, which at the time of death may average about 40 per cent of the original weight.

The passage of characteristic bright green droppings is commonly observed within 2 days after ducks are dosed with commercial shot pellets. Following frequent ingestion of water by the ducks, a greenish diarrhea is produced. Staining of the vent is observed in some but not all cases.

During the second and third weeks of illness, the birds show signs of weakness and fatigue; their

whole appearance is one of reduced vigor. During the third and fourth weeks the above symptoms increase in severity, and new symptoms appear. The keel bone becomes prominent, and the wings generally assume a "roof-shaped" position over the back (see cover illustration); penned ducks in this stage

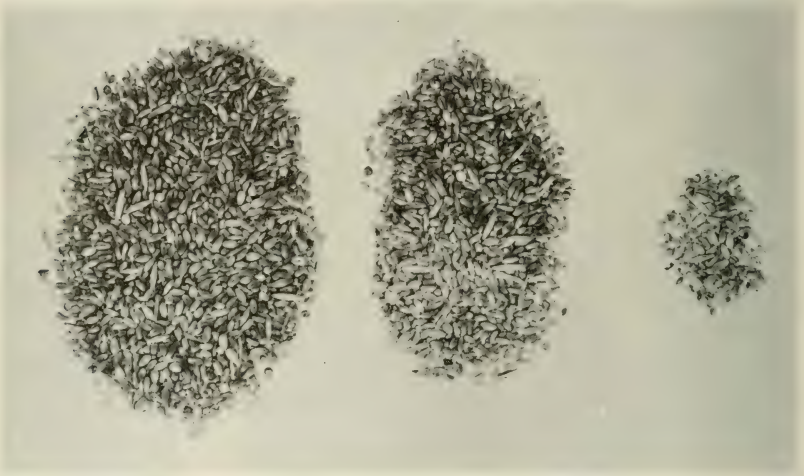

Fig. 4. -- Three lots of small grains that illustrate the effect of ingested lead shot on the average daily intake of food by three wild drake mallards. Left to right are (1) 0.19 pound, consumed by a duck that exhibited no ill effects following the dose of shot (2) 0.11 pound, consumed by a duck that showed moderately ill effects and a weight loss of 0.5 pound, and (3) 0.01 pound, consumed by a duck that lost 1.4 pounds and died 19 days following the administration of shot.

of poisoning are unable to fly. Wild, unpenned ducks make weak attempts to fly or dive when they are flushed, or they seek concealment in vegetative cover. In some cases the wings of sick ducks are extended downward in a "wing drop," fig. 5, and attempts to retract them usually fail.

A combined drooping of the chest and abnormally high carriage of the tail impart an unsteady, rocking motion to the birds as they move about. The neck invariably rests on the back. Ducks commonly fall and experience difficulty in arising. Lead-poisoned birds, both in the pens and in the wild, seek isolation.

The blood of ducks in advanced stages of poisoning is thin and anemic in color.

Symptoms in Dead Ducks. -- Dissection of lead-poisoned birds reveals striking evidence of emaciation. The body cavity contains no fat deposits. The great flight muscles of the breast are reduced

Fig. 5. -- Wild mallards severely affected by lead poisoning in an outbreak of this malady in January, 1948, near Grafton, Illinois. The two hen mallards at the right in this scene had reached a late stage of lead poisoning in which the wings are extended downward in a "wing drop." Note the carcass in the foreground partly eaten by a predator, a fate that befalls most ducks incapacitated by lead poisoning. (Photograph from Olin Industries, Inc.)

to remnants of their former size, fig. 6. The liver and kidneys also show wasting effects. In many cases, the membranous sac enclosing the heart is distended by a watery effusion. The heart itself is flabby and reduced in size. The intestines are in a similar condition. In some instances, the enlarged gall bladder weighs five times its normal weight.

In most cases the gizzard is abnormally small. Ingested shot, if present, while usually in the gizzard, is occasionally found in the glandular stomach immediately before it. It was found that 22 per cent of the experimental mallards dying from the effects of lead poisoning had voided their shot a short

time before death. The horny lining of the gizzard often shows no outward evidence of change. Generally, however, a green or dark brown stain colors both the lining and gizzard contents. The horny pads may be uncommonly stiff, abnormally rough, and easily peeled. Ulcerated areas, each about as small as a match head to as large as a kernel of corn, penetrate to the soft underlining.

Fig. 6. -- Two plucked mallards, one healthy when killed, one that died from lead poisoning. High weight losses are associated with severe cases of lead poisoning. The mallard shown at the right lost 1.1 pounds (a decrease in weight from 2.4 pounds to 1.3 pounds) and died on the twenty-fourth day following a dose of two shot pellets. The mallard shown at the left was undosed and when sacrificed was at its normal weight of 2.6 pounds.

In 44 per cent of the penned ducks dying from lead poisoning, the glandular stomach was impacted by food, fig. 7, indicating a failure of the gizzard to keep pace with even a lowered food intake. Other observations furnished additional evidence of reduced activity of the gizzard muscles. In some ducks, the gizzard is distended by undigested food.

Fig. 7. -- Two gizzards, one from a mallard dosed with lead. Food impaction of the glandular stomach commonly occurs in lead-poisoned mallards. The glandular stomach attached to the gizzard shown in upper part of illustration was distended by small grains. No fat deposits were found around the gizzard. The proventriculus and gizzard shown in lower part of illustration were removed from an undosed mallard.

LEAD-POISONED DUCKS AS FOOD

Some sportsmen have asked if they themselves can become poisoned by eating the flesh of ducks that are suffering from lead poisoning.

That the flesh of lead-poisoned ducks can be eaten by human beings without ill effect is indicated by studies made with laboratory animals that received doses of lead salts. Analyses of muscle and skin of these animals for lead content generally failed to reveal the presence of lead deposits. The liver and kidneys are more likely to contain lead than the muscular tissue; yet the livers of lead-poisoned ducks were found to contain amounts of lead of negligible significance to human beings.

A further protection against the transmission of lead poisoning from ducks to human beings lies in the fact that waterfowl severely affected by lead poisoning are too emaciated to be regarded as suitable for the table.

OCCURRENCE OF LEAD POISONING

Waterfowl deaths attributed to lead poisoning have been reported from practically all sections of the United States. A list of localities where lead poisoning has been known to afflict waterfowl includes Delaware Bay, Delaware; Pamlico Sound, Virginia; the coast of North Carolina; Houghton Lake, Michigan; Lake Erie marshes, Ohio; Hovey Lake, Indiana; Green Bay, Wisconsin; the Illinois River valley, Illinois; Forney Slough, Iowa; Dalton Cutoff, Chariton County, Missouri; Claypool Reservoir, Arkansas; Catahoula Lake and the coastal marshes of Vermilion Parish, Louisiana; Sand Lake, South Dakota; Boyd Lake, Colorado; Bear River marshes, Utah; Snake River valley, Idaho; and Nehalem Bay, Oregon.

Most of the reported losses from lead poisoning have occurred during late fall or winter; however, appreciable losses from lead poisoning have occurred among diving ducks during the spring.

Outbreaks. -- Sporadic die-offs of waterfowl from lead poisoning increase in number and severity as the birds tend to concentrate on heavily shot-over areas where abundance of food on bottoms entices the birds into intensive feeding. They occur usually at or near the end of the hunting season when the supply of shot pellets is abundant and before the pellets have penetrated deep into the muck or have been covered by a layer of silt. Lack of availability of certain wild foods, often at this time restricted by ice and snow, constitutes a factor that may also account for the local and seasonal nature of outbreaks of lead poisoning in waterfowl.

Almost every year in the past 12, we have found wild ducks in Illinois that were disabled or dead from lead poisoning. Most spectacular losses have occurred after the end of the hunting season, when ducks have moved from refuges to heavily shot-over areas to feed. With the subsequent freezing weather of midwinter, the effect of lead poisoning has been brought into sharp focus, for large numbers of the ailing birds have moved into relatively small open-water areas where dead and dying ducks could be readily observed.

The largest recorded outbreak of lead poisoning among Illinois ducks occurred near Grafton in January, 1948. There were about 110,000 ducks, most of them mallards, wintering in the area. Soon after the end of the hunting season on November 27, they moved from Swan Lake, a United States Fish and Wildlife Service refuge, to a public shooting ground, known locally as Stump Lake. Evidently, in feeding upon seeds in the bottom silt of the shallow water area, many mallards picked up lead shot. A few weeks later, with the lake almost completely frozen over, Edward Davis, Refuge Manager, began to notice sick mallards on the ice and seeking concealment in the shore-line vegetation, fig. 8. Autopsy revealed lead shot in the gizzard of nearly every duck examined. A tally of the dead ducks revealed that

Fig. 8. -- A group of about 25 incapacitated mallards, each of which apparently had ingested shot pellets before succumbing to lead poisoning near Grafton, Illinois, in January, 1948. Lead-poisoned ducks frequently seek concealment in shore-line vegetation. (Photograph from Olin Industries, Inc.)

from 2,000 to 3,000 died on this occasion. Although the total seems large, it represented less than 3 per cent of the duck population in the area. In January, 1947, approximately 200 ducks that had died in a single week from lead poisoning were counted in the same area. At that time there were about 10,000 mallards present.

The problem became acute in this area only recently, for large numbers of hunters did not concentrate here until it was established as a refuge and public shooting ground in 1942. From that time to the end of the 1946 season, these shooting grounds were frozen over by the end of the season, thereby preventing waterfowl from reaching the shot. During the spring floods the pellets were beneath deep water. Dabbling ducks could not reach them, and diving ducks were seldom abundant in this area.

Day-to-Day Losses. -- Although local outbreaks of lead poisoning in waterfowl appear alarming, actual known losses in any one year have been but a small fraction of the total waterfowl population. Greater waterfowl losses from lead poisoning have been thought to lie in the dispersed, day-to-day mortality that usually goes unnoticed in the extensive areas utilized by waterfowl.

It is possible to make an evaluation of the extensive day-by-day mortality from lead poisoning by (1) determining the incidence of ingested lead shot in fall waterfowl populations, fig. 9, and (2) experimentally evaluating in wild waterfowl populations the mortality resulting from various administered doses of pellets.

Fig. 9. -- A fluoroscope unit used as an aid in determining the incidence of ingested commercial shot pellets in live-trapped waterfowl. Ducks were placed in the cone shown in the illustration and rotated before the fluoroscopic screen. By this method a technician could recognize and locate the position of lead shot within the body of a duck.

Proportion of Ducks With Ingested Lead. -- Examination of the gizzard contents of more than 18,000 ducks taken by hunters revealed that the proportion of gizzards with ingested shot varies among regions of the United States, fig. 10. The proportion of ducks swallowing shot is greatest in the southeast Atlantic and Gulf of Mexico coastal regions. In the Great Plains region, where hunters are relatively few in number, the proportion of ducks with ingested shot is unusually low.

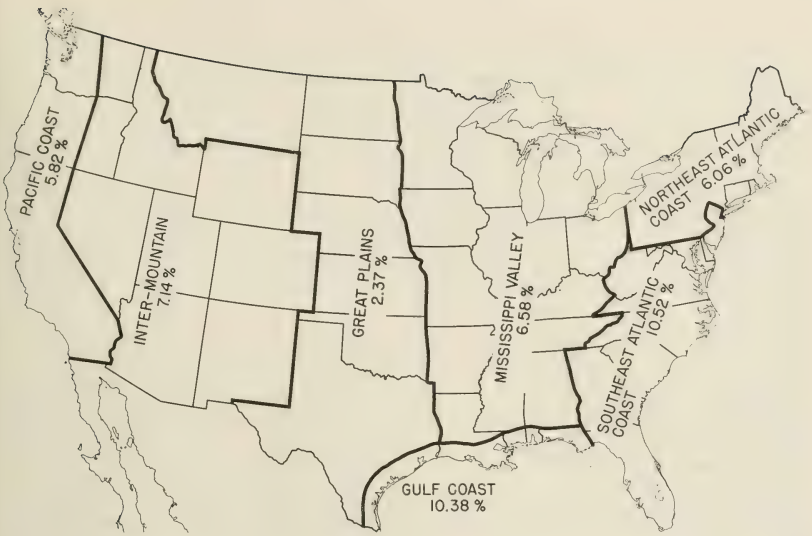

Fig. 10. -- Percentage of waterfowl populations carrying ingested commercial shot pellets in autumn and early winter. Data for six regions of the United States are based upon an examination of 22,071 gizzards collected in recent years.

The proportion of ducks that swallow shot while feeding, as revealed by examination of gizzard contents, varies among the different species, fig. 11, indicating that lead poisoning losses may be higher for some kinds of ducks than for others. Whether they are actually higher can be determined only by further study.

The great difference between the less than 1 per cent of the gadwalls and the more than 13 per cent of the redheads swallowing lead shot suggests a basic relationship between the quantity of ingested shot and the feeding traits and habitat of each kind of waterfowl. It seems likely that relatively few gadwalls and baldpates swallow shot because they feed on leafy plants rather than on seeds in the bottom soil. Shovelers and green-winged teals feed on mud flats and in shoal water areas where they apparently skim the surface rather than puddle into the bottom silt. Probably in feeding on the surface they come into contact with lead less frequently than do mallards and pintails, both of which have been found to puddle 6 inches or more through the bottom silt for food. Blue-winged teals, which apparently puddle more than do green-winged teals, have a higher proportion of gizzards containing shot, even though the blue-wings

migrate earlier when less shot is available. Ring-necked ducks, canvasbacks, and redheads, which show a high proportion of gizzards containing ingested lead, usually dig for seeds and tubers of aquatic plants,

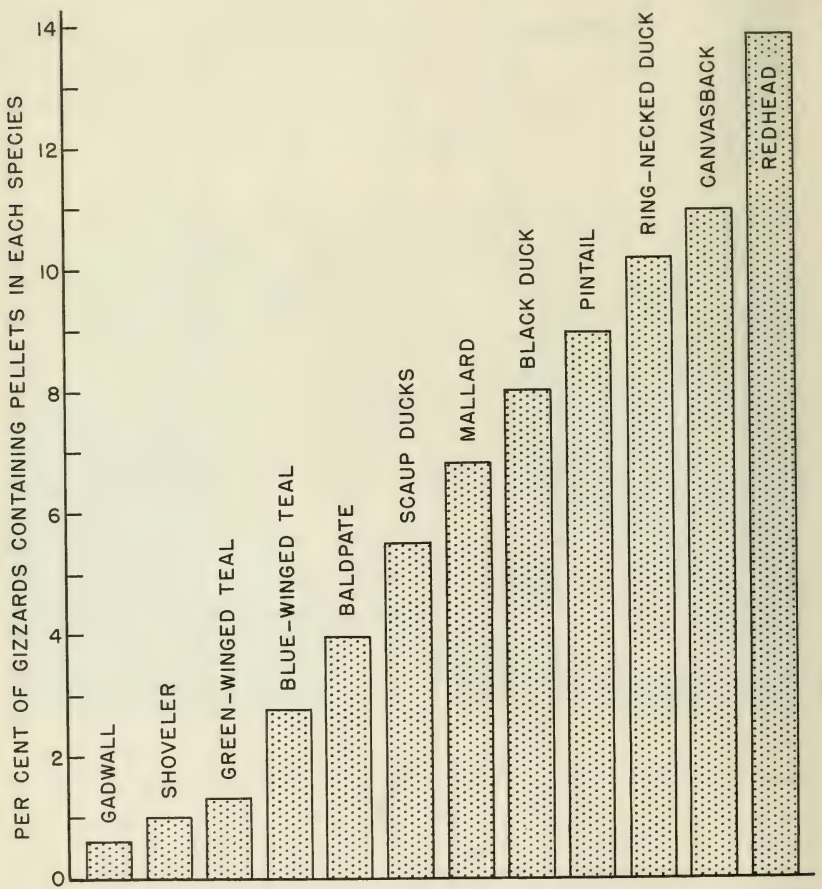

Fig. 11. -- Occurrence of commercial shot pellets in the gizzards of 18,454 ducks of various species. The gizzards were collected in recent years from many parts of the United States in autumn and early winter.

and beds of such plants are extensively shot over during the hunting season. Scaup ducks, in feeding largely on animal life in deeper waters, are perhaps less likely to come in contact with deposited shot.

In general, the death rate in wild, unpenned ducks is higher among birds ingesting several pellets than among birds ingesting one pellet. Therefore, it is important to determine the frequency of the various numbers of shot pellets taken. Among 18,115 gizzards examined, 5.28 per cent contained ingested shot. Of those containing shot, 69.3 per cent contained only one pellet; 13.0 per cent contained two pellets and 17.7 per cent contained more than two pellets, fig. 12. This rate of ingestion applies to general conditions. The rate is, of course, higher among duck gizzards collected in severe outbreak areas.

EFFECT OF INGESTED LEAD SHOT ON WILD DUCKS

The effect of ingested lead shot on wild mallards is under evaluation through a field experiment. Banded mallards are being used as undosed control birds for purposes of comparison with other banded mallards dosed with lead shot. Bands returned have revealed differences between the dosed and undosed birds in mortality rate, hunter kill, and rate of migration.

During the fall of 1949, two groups of trapped wild mallards were banded and released: (1) 560 undosed and (2) 559 with one no. 6 shot pellet each. In 1950, three groups were released in the experiment: (1) an undosed control group of 389 ducks, (2) 391 ducks with one no. 6 pellet each, and (3) 392 with two no. 6 pellets each.

Band returns show that in the year of banding a significantly greater number of ducks were killed from groups dosed with lead than from undosed groups, fig. 13, indicating that ducks suffering from lead poisoning during the hunting season are more readily bagged than are the more healthy ones. Some of the lead-poisoned ducks shot by hunters are on the credit side of the mortality ledger; since the upper limit of the total take is governed by regulations, these birds become part of the planned harvest. This reduces the waste resulting directly from lead poisoning and is one reason so few ducks are found dead from lead poisoning during the hunting season.

Band returns in the year of banding were sufficiently numerous from the 1950 release to determine the difference in the rate of movement between healthy and lead-poisoned mallards, fig. 14. Ducks in the undosed group averaged about 7 miles per day between the place of banding and that of shooting. Ducks dosed with one pellet each averaged only about 5 miles per day, and those dosed with two pellets each averaged slightly more than 4 miles per day. Thus, it seems evident that migration of lead-poisoned ducks is retarded.

DETERMINING MORTALITY RATES

A start has been made toward evaluating lead poisoning losses among wild, unpenned ducks swallowing only one shot pellet. The difference in second-year band returns between an undosed group and a group dosed with one shot pellet each should represent the mortality rate caused by one shot pellet per bird if no compensating adjustments are involved.

A total of 113 bands was reported taken during the 1950 season from 1,119 wild mallard drakes used in the 1949 experimental release of dosed and undosed birds. Fifty-five of the 113 were from the

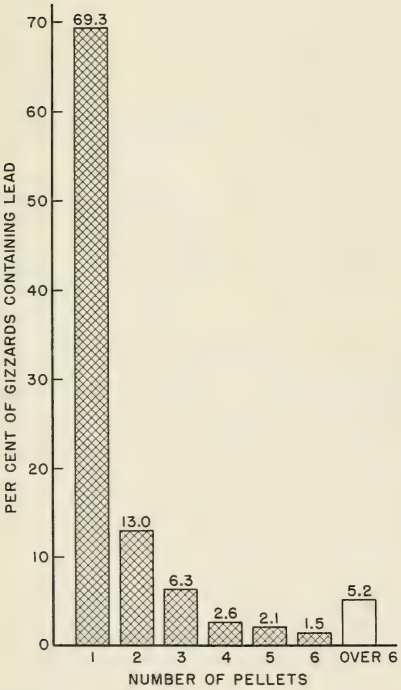

Fig. 12. -- Percentage of wild duck gizzards containing various numbers of commercial shot pellets. Data are for 957 gizzards that contained shot in a total number of 18,115 gizzards collected in recent years, fall and early winter.

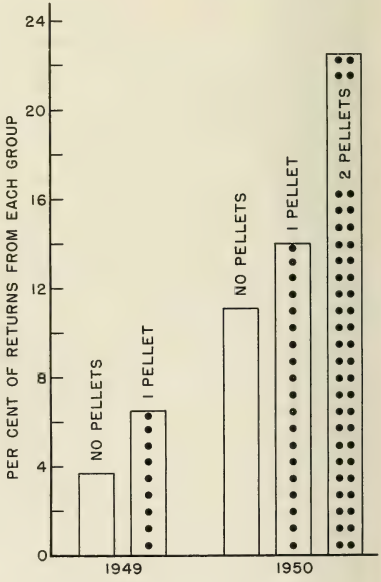

Fig. 13. -- Percentage of birds in five groups of banded wild mallards that were reported killed (by return of bands) in year of banding. In 1949 about 560 mallards were banded in each of two groups, one group carrying no lead and the other one no. 6 pellet to each bird. In 1950, about 390 were banded in each of three groups, one group carrying no lead, one group one no. 6 pellet to each bird, and one group two no. 6 pellets to each bird.

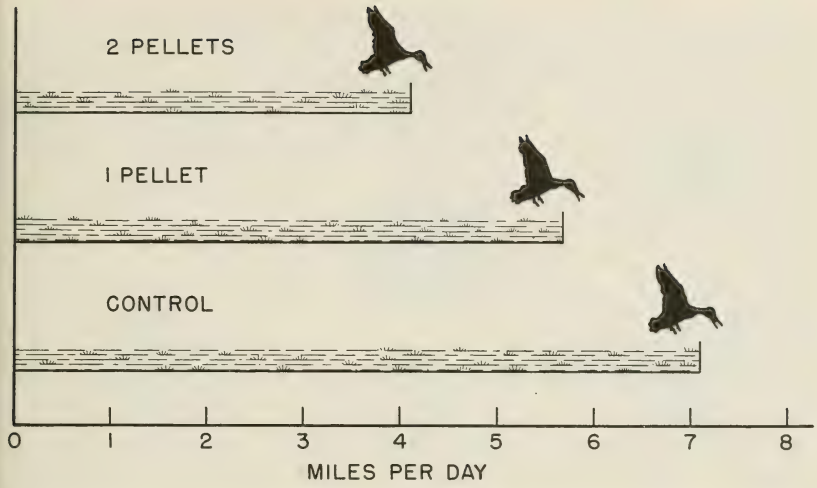

Fig. 14. -- Number of miles per day averaged by three groups of ducks after they were trapped, banded, and released, and before they were shot by hunters, 1950. One group was dosed with a single no. 6 commercial shot pellet, one group with two pellets, and one group, the control group, was undosed.

group dosed with one pellet and 58 from the undosed control group. This slight difference in returns between the two groups indicates that, entering the 1950 hunting season, almost equal numbers of mallards were alive in the two groups. Because of the known greater loss among birds in the dosed group to hunters in 1949, fig. 13, a greater difference should have been found in 1950 even though no allowance is made for the possibility of additional mortality among the dosed birds as a direct result of lead poisoning.

Although results are based on but 1 year's observation, the lead-poisoning loss among birds dosed in the 1949 field experiment apparently was inconsequential enough to have been almost completely compensated for by "normal" losses among the birds of the control group during the period between the close of the hunting season in 1949 and the opening of the season in 1950.

At the present time, for mallard drakes ingestion of not more than one shot pellet by any one bird does not appear to constitute an important depressive influence on the population. This is especially significant because most ducks (69 per cent) that swallow lead shot swallow only one pellet each.

If we can generalize from the above data, we may say that the day-to-day loss of ducks from lead

poisoning, throughout North America, is less serious than previously thought -- with the possible exception of such species as the redhead, the numbers of which have been seriously depleted in recent years.

The proportion of wild drake mallards held under artificial conditions of captivity that died from the effects of one shot pellet each generally exceeded that of birds dosed with one shot each and released in the wild. It is thought that the higher mortality rate may be largely because the penned mallards had no choice of food other than that provided.

INFLUENCE OF DIET

Experimental feeding of penned ducks showed that food has an important influence on the effect of lead shot ingested by waterfowl.

Influence of Nutritional Properties. -- Chemical analyses made in the Department of Animal Science, University of Illinois, of several of the foods fed to lead-dosed ducks in early experiments suggested that certain nutritional properties tended to alleviate the effects of lead. Attempts were made to simulate diets containing these nutritional properties by adding, as supplements to whole corn, protein, calcium, phosphorus, calcium phosphate, or vitamin C. The results of these experiments did not correlate well with results of the early experiments. It is evident that nutritional constituents alone probably are not responsible for the moderating influence of certain diets on lead poisoning.

Influence of Physical Form. -- Experiments with captive mallards indicate that the effect of ingested lead is influenced by the physical form of food in the diet, fig. 15. The harmful effect of ingested lead was most evident in the birds fed on whole corn, preferred by fall migrating mallards in Illinois. It was less evident in the birds fed on seeds of smaller size, such as wheat, tame rice, smartweed, and wild millet. It was still less evident in birds, feeding on corn or on corn and small grains, to whose diet was added the green parts of such aquatic plants as sago pondweed, duck weed, and coontail, figs. 16 and 17. It was least evident in those birds fed on commercial duck pellets, which, upon coming into contact with moisture, break down into a soft mash.

The influence of physical form was clearly shown when one group of game-farm mallards dosed with lead shot was fed whole corn and another corn ground to a meal. By the end of the third week, the group on whole corn had suffered a greater reduction in food consumption, higher weight losses, and a higher mortality rate than the group fed corn meal.

Influence of Food Preference. -- Captive wild mallards dosed with lead showed different degrees

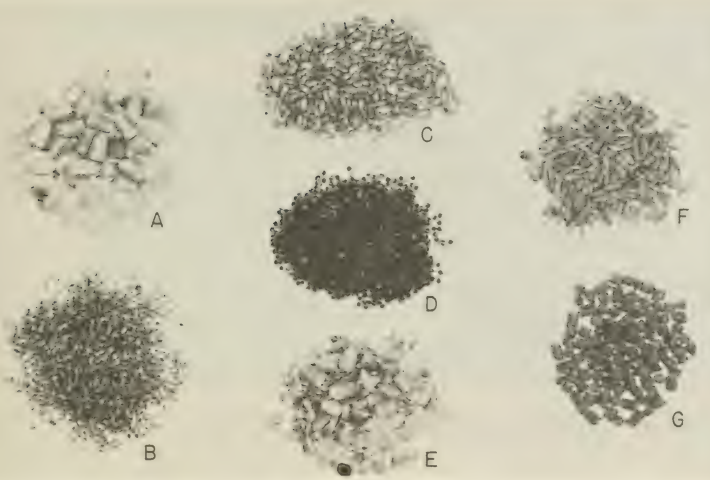

Fig. 15. -- Various diets supplied to ducks in experiments on lead poisoning: A, corn; B, millet; C, small grains; D, smartweed; E, mixed grains; F, tame rice; G, commercial duck pellets.

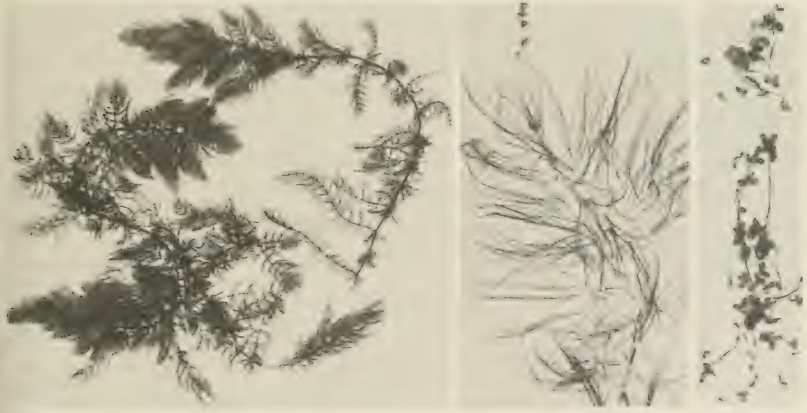

Fig. 16. -- Succulent parts of leafy aquatic plants helpful in reducing the effects of lead. Left to right are coontail (Ceratophyllum demersum L.), sago pondweed (Potamogeton pectinatus L.), and duckweed (Lemna minor L.).

Fig. 17. -- Coontail being fed to a group of penned wild mallards. This valuable food plant, after being air dried, was readily eaten by mallards following its immersion in water.

of preference for the various foods available to them. With one exception, the foods associated with the highest survival rates in lead-poisoned ducks were the ones usually preferred. Corn was the exception. In one instance, a preference shown by lead-dosed mallards for corn from a mixture containing 73 per cent small grains partly nullified the more favorable influence of the small grains. In another case, a shift of preference from corn and small grains to commercial duck pellets resulted in a higher survival of lead-poisoned mallards than otherwise might have occurred. Canada geese on a diet of whole yellow corn and duck pellets were severely affected by a dose of two no. 4 shot pellets as long as they continued to feed on corn, but all except one recovered when they shifted to duck pellets. Undosed control geese continued to feed almost exclusively upon corn throughout the experiment.

Influence of Rate of Food Consumption. -- Measurements of the amounts of food eaten by lead-dosed mallards revealed that symptoms of lead poisoning failed to appear in those birds that maintained a normal or nearly normal rate of food intake. It was found, also, that the effect of lead varied with the amounts of food consumed by mallards grouped by age, sex, and history of captivity. When dosed with shot pellets, game-farm mallards ate more both before and after treatment than did penned wild mallards, and wild mallards were more susceptible to the effects of lead. The food intake of 8-week-old juvenile game-farm mallards greatly exceeded that of adults both before and after each group was

dosed. The juveniles suffered no apparent effect from the lead, whereas the adults suffered a 30 per cent mortality and an average weight loss of 19 per cent.

The hen mortality from lead poisoning was found to be double the drake mortality, except in the spring season when hens entered the breeding phase. At this season the food intake of penned wild hens increased steadily until it equaled, then exceeded, that of penned wild drakes. During this period hens proved to be less susceptible to lead poisoning than were drakes. At all other seasons hens ate less food than did drakes.

Low air temperatures encouraged a greater consumption of food by both dosed and undosed penned mallards, and the proportion of dosed birds surviving in winter was greater than that in milder seasons. In late fall and winter, mallards that died of lead poisoning did so in an average time of about 23 days following the ingestion of shot.

Evaluation of the results of experiments on the influence of food revealed that the diet, rather than the level of the shot dose (within a range of four or fewer no. 6 pellets), was the more important variable in lead poisoning.

LEVEL OF THE SHOT DOSE

Among penned ducks on comparable diets, an increase in the shot dose beyond a single no. 6 pellet to a top limit of four pellets generally was followed by a corresponding increase both in the proportion of ducks affected and in rate of mortality. There were enough exceptions, however, to indicate that the range of susceptibility varied within wide limits. In some mallards, one pellet was sufficient to produce severe symptoms, while in others doses of one, two, three, or four no. 6's had little or no effect. Apparently, each duck possesses an individual critical point of tolerance to lead.

Preliminary work suggests that this critical point of tolerance may be related to the rate of food intake. Mallards that appeared to be fully recovered from the effects of doses of two or three no. 6's were found to be eating more food than those with no history of lead poisoning.

Among penned ducks, an increase in the dose did not increase the severity of lead-poisoning symptoms, nor did it shorten the survival period of sick ducks. Post-mortem weights of poisoned ducks, regardless of the dose, were lowest during warm weather periods and highest during cold weather.

RECOVERY FROM LEAD POISONING

Recovery of sick mallards seemed to be influenced by one or both of two conditions: (1) natural passage of shot from the gizzard and (2) sufficient food intake to replace high weight losses. Most ducks that eliminated shot recovered, but their rate of recovery was slow if they were on an inferior diet. Most ducks that ate with renewed appetites, when a better diet was substituted, made rapid recovery whether they had eliminated or retained the shot. For example, 50 wild mallard drakes that were moderately or severely affected suffered an average weight loss of nearly three-quarters of a pound within an average of 22 days after being dosed. Twenty-eight days after being dosed they were placed on a better diet. In an average time of 26 days after the better diet was substituted, these same birds had regained all but an average of about one-tenth of one pound.

A few severely affected individuals regained in the first week of their recovery period nearly all of the weight lost during 4 weeks of the experimental period. Examination by Dr. Paul D. Beamer, College of Veterinary Medicine, University of Illinois, of samples of the livers and kidneys from recovered ducks failed to show the presence of any abnormalities caused by lead.

Not all sick mallards recovered even when offered an optimum diet of duck pellets. Many were in such wretched condition that they either failed to eat or were "too far gone" to survive for more than a few days.

RELATION OF STARVATION TO LEAD POISONING

The behavior of lead-poisoned mallards, post-mortem examinations of those that died, and the phenomenal recoveries made by others led to the hypothesis that lead-induced starvation was the immediate cause of death. In order to test this hypothesis, mallards were paired, the age and sex of both birds of each pair being the same. One of each pair was fed a single no. 6 shot and the other was undosed. Food intake of the dosed bird was measured daily and exactly this amount was fed to its companion the following day. In nearly all pairs the weight loss curves, symptoms, and mortalities were remarkably similar.

With minor exceptions, the gross appearance of the viscera, muscles, and blood of ducks from which adequate food was withheld was indistinguishable from that in lead-poisoned ducks. The glandular stomach, however, was never impacted, nor was food recovered from the digestive tract. The horny lining of the gizzard, moreover, exhibited none of the effects commonly caused by direct action of lead. The lining invariably was stained dark brown.

Of the living birds, recovery was more rapid in victims of deliberate starvation than in those suffering from lead poisoning.

SUBSTITUTES FOR COMMERCIAL SHOT PELLETS

Lead, arsenic, and antimony are the three metallic components of commercial shot pellets. Of these, only lead produces ill effects when fed to ducks; tests showed that arsenic and antimony in quantities greater than ducks would be likely to ingest along with lead shot under natural conditions were not injurious. Efforts were made to develop alloy shot that would either neutralize the effect of lead or hasten its elimination from the gizzard.

Disintegrating Shot Alloys. -- It has been suggested in the literature that if magnesium is used in commercial shot pellets in place of arsenic and antimony, an alloy will be produced that will disintegrate in a duck's gizzard and be eliminated harmlessly within a day or two. When fed to ducks eating grain diets, however, pellets containing 2 per cent magnesium were found in our study to fragment slowly and produce severe cases of lead poisoning, possibly as a result of the increased surface area of lead exposed in the gizzard. Other pellets of this magnesium content failed to disintegrate in natural waters within a reasonable time, thereby removing the possibility that they would be unavailable to ducks feeding in shot-over areas.

A disintegrating alloy of lead-calcium also was experimentally produced and fed to mallards, but results were similar to those following the use of commercial shot.

Other Alloys. -- The poisoning effect of pellets made of a lead-tin-phosphorus alloy was tested because patents covering the manufacture of this alloy claimed that, when ingested, it would be nontoxic to waterfowl. However, the mortality rate for game-farm mallards dosed with this shot alloy proved to be higher than that for game-farm mallards dosed with commercial shot.

Lubaloy shot, a commercial product consisting of a lead alloy thinly coated with a copper alloy, was no less toxic to mallards than commercial shot. The copper alloy was soon worn away by gizzard action, exposing the lead to erosion. A slight advantage was obtained in that the copper alloy delayed the availability of lead within the gizzard for about 4 days.

Large doses of iron shot produced no ill effects when fed to wild mallards. Iron shot pellets are not at present commercially available, but further research is being conducted on their production and use.

ALLEVIATING LEAD POISONING

Inasmuch as there is at present no satisfactory method of eliminating the lead-poisoning hazard, it is possible only to suggest measures that should reduce waterfowl losses from this source.

Increasing Natural Food Resources. -- The development of more extensive stands of certain natural foods is a possible remedial measure, fig. 18. As has been demonstrated in pen experiments, the form of the food consumed, as well as the quantity, is important in survival of ducks suffering from this malady.

Fig. 18. -- Stand of wild millet located on premises of a private duck-shooting club near Bath, Illinois. Such stands of natural foods are important in reducing the effects of ingested lead.

Of the foods tried, the most desirable for alleviating lead poisoning were leafy, green, aquatic plants. Coontail was especially good. Next in value to leafy vegetation were small seeds, such as those of millet, smartweed, and tame rice. Corn was the least beneficial.

Through management it is possible to encourage the growth of those natural foods most likely to alleviate lead poisoning in ducks. By providing the proper depth and clarity of water, coontail or sago pondweed can often be increased in abundance. By reducing water levels to expose mud flats, beds of millets, smartweeds, and other moist-soil plants can be developed; the beds must then be flooded to make the seeds available to ducks.

Dispersal of Ducks From Problem Areas. -- Known focal points for lead-poisoning outbreaks should be given particular attention. After the hunting season is over, it is often possible to prevent large numbers of ducks from congregating on such areas by employing scare devices.

Many devices have been used to scare waterfowl from grain fields. Tracer bullets, mortar bombs, revolving lights, and burning oil drums are among those that have been successfully employed to scare waterfowl. Edward Davis, Refuge Manager, Calhoun County National Wildlife Refuge, successfully kept mallards from congregating in the adjacent Stump Lake public shooting ground after the close of the 1949 and 1950 hunting seasons. He accomplished this by using gun fire to flush the birds repeatedly.

Hunter Conduct. -- The individual hunter can reduce waterfowl losses from lead poisoning by exercising greater control over his shooting.

It is a common practice among hunters to underestimate the distances at which ducks and geese are flying. Large ducks and geese, particularly, seem to be closer than they really are. Recognition of color patterns, the eyes, the feet, or other features are used by some hunters as a guide for telling when birds are within range. This rule of thumb is effective only on bright days, and due allowance must be made for dark or misty days. Many hunters find it helpful to take note of the distance from the blind to the decoy spread or to some landmark, such as a muskrat house or snag, as a means of judging range.

Perhaps the best method for estimating range involves calibrating the width of the shotgun muzzle on a 20-inch square of paper at distances of 30 to 60 yards. The length of most ducks in flight is approximately 20 inches, and the width of the flesh-and-bone area of the wing spread is approximately the same. The relationship between the width of any type of gun muzzle and a flying duck can be worked out in a few minutes against a 20-inch square of paper. For example, if the muzzle of a 12-gauge double-barreled shotgun completely covers a mallard or other large duck, that duck is too far away to shoot.

Out-of-range shooting creates two undesirable conditions: (1) a needless deposition of large numbers of expended pellets in shot-over areas and (2) an unnecessarily large number of unretrieved cripples. Because the proportion of unretrieved cripples is roughly one-third of the number of ducks bagged, and about 8 per cent of Illinois mallards have swallowed shot pellets, it is at once apparent that an improvement in hunters' judgment, self-discipline, and choice of duck loads may, by reducing lead-poisoning and crippling losses, increase the number of ducks bagged or available for shooting.

Preliminary results of a co-operative investigation by Olin Industries, Inc., and the Illinois Natural History Survey show that, at ranges up to 50 yards, there are only small differences in the effectiveness of standard loads of shot sizes nos. 4 and 6. Although beyond 50 yards the killing power of both sizes drops, no. 4's are noticeably more effective than the smaller shot size. Shells of this shot size contain 40 per cent fewer pellets than do no. 6's, and their use by hunters would reduce the number of expended shot pellets available to feeding waterfowl.

SUMMARY

1. Lead poisoning is likely to occur in wild waterfowl that have swallowed lead shot pellets obtained while feeding in shot-over areas.

2. The grinding action of the gizzard and chemical action of the digestive juices erodes and dissolves the ingested lead shot. Lead compounds that are formed appear to have a direct, damaging effect on the smooth muscles of the digestive tract, and, after being absorbed by the blood stream, a harmful effect on the liver and kidneys. Lead poisoning is the name given to the pathological condition that results.

3. Ducks severely affected by lead poisoning eat little or no food and suffer marked weight losses. Weakness, fatigue, and exhaustion are the most common symptoms in lead-poisoned ducks. Ducks that die of lead poisoning are emaciated; vital organs and muscles are abnormally small, and the gizzards show evidence of decreased activity.

4. Available evidence indicates that the flesh of lead-poisoned ducks can be eaten by human beings without ill effect.

5. Outbreaks of lead poisoning in wild waterfowl usually occur late in fall or in winter after large numbers of ducks have moved to heavily shot-over areas to feed.

6. Day-to-day losses in wild waterfowl can be evaluated by determining the proportion of birds with ingested lead shot, the numbers of pellets in the gizzards, and the rates of mortality produced by given numbers of pellets among waterfowl in a wild state.

7. The incidence of ingested lead shot varies from 1 to 13 per cent among the different species of wild ducks studied. Differences in the incidence of shot among species are attributed to variations in methods of feeding and in types of habitat preferred.

8. Of 18,115 duck gizzards collected from many parts of the United States and examined, 5.28 per cent contained ingested lead shot. Of those containing shot, 69.3 per cent contained one pellet, 13 per cent two pellets, and 17.7 per cent more than two.

9. Band returns from wild mallards dosed with shot pellets and from approximately equal numbers of undosed wild mallards banded and released at the same time showed that the birds dosed with lead shot did not fly so far as undosed birds before being bagged; also they were more vulnerable to shooting.

10. The ingestion of not more than one shot pellet by any one duck did not appear materially to lower the numbers of wild drake mallards from one year to the next.

11. Food was found to have an important influence on the effect of the lead shot ingested by penned waterfowl:

a. Corn and added supplements of one or more important nutritional elements failed to furnish a satisfactory substitute for natural foods of similar constituents in alleviating lead poisoning among penned waterfowl.

b. Penned ducks fed on food items of small size and the succulent parts of aquatic waterfowl food plants were affected less by lead poisoning than those fed on food items of large size and greater hardness.

c. Some penned mallards and Canada geese suffering from lead poisoning increased their chances for survival when they shifted their food preferences to smaller and softer food items.

d. Symptoms of lead poisoning failed to appear in lead-dosed, penned mallards that maintained a normal rate of food intake. The amount of food consumed varied with sex and age, and the effect of ingested lead varied accordingly.

12. Captive wild mallards showed individual differences in tolerances to lead doses. These differences seemed to be related to corresponding differences in the amounts of food consumed under normal conditions.

13. Increasing the shot dose (within the limit of four pellets) administered to penned mallards was found (1) to increase the proportion of ducks affected, (2) to increase the rate of mortality, but (3) not to increase the severity of symptoms nor (4) to shorten the survival period of poisoned ducks.

14. Some severely affected penned mallards apparently recovered from lead poisoning following elimination of shot or renewal of appetite.

15. Lead-induced starvation appeared to be the immediate cause of death in lead-poisoned mallards.

16. Of the three metallic components (lead, arsenic, and antimony) of commercial shot, lead was found to be the only one to produce ill effects when fed to ducks.

17. With the effects of commercial shot used as a standard, lead-magnesium, lead-calcium, lead-tin-phosphorus, and copper-coated lead-shot pellets were evaluated in the search for a possible means of eliminating or reducing lead-poisoning losses among waterfowl. None showed promise under the conditions of these experiments. Iron shot was found to be nontoxic to penned mallards, but this shot is not now available commercially.

18. At the present time only stopgap measures can be undertaken to reduce wild waterfowl losses from lead poisoning. The following remedial measures are suggested: (1) Increase the amounts of certain natural waterfowl food plant resources, (2) disperse waterfowl from known focal areas of lead poisoning, (3) exercise greater care in shooting and thereby reduce the cripple loss as well as the amount of expended lead pellets deposited on the feeding grounds of waterfowl.